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Standard Operating Protocols for Bottom Longline Surveys

U.S. Department of Commerce
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Southeast Fisheries Science Center

TABLE OF CONTENTS

Southeast Fisheries Science Center (SEFSC) Historical Overview of Bottom Longline Surveys

The SEFSC began collecting fisheries resource data in the Gulf of Mexico (GOM), Caribbean Sea and Atlantic Ocean in 1950. Over the years, SEFSC has conducted a number of projects using longline gear. The projects have targeted a variety of species including swordfish, bluefin tuna, tilefish, reeffish and sharks. The historical data base contains numerous records of surface, off-bottom and bottom longline sets in the GOM, western North Atlantic and Caribbean.

Most of the longline work in the 1950s and 1960s was exploratory in nature, and the main intent was to identify underutilized resources that might support commercial fisheries. Gear used in early surveys was “Yankee gear” or rope-type gear, that has been demonstrated to be less efficient than currently used monofilament mainlines. Most exploratory work was non-random in nature and while useful in qualifying catches it was not particularly good for quantifying catch. It was not until the early 1970s with the abolition of the Bureau of Commercial Fisheries

(BCF) and formation of the National Marine Fisheries Service (NMFS), that serious consideration was given to standardized sampling to facilitate population estimation.

During the 1970s and 1980s, several studies were conducted to determine whether longline gear would be useful for stock assessment surveys. Those studies were target-specific directed efforts that yielded mixed results using surface, off-bottom and bottom longline gear. None of those studies led to implementation of long-term stock assessment surveys.

Prior to 1995 there were few fishery-independent scientific surveys of small and large coastal shark populations in the U.S. GOM, and only sporadic or localized surveys had been conducted along the U.S. Atlantic coast. Beginning in 1995, the SEFSC initiated a pilot study to develop survey methodology and a sampling strategy for assessment of coastal shark populations in the GOM. Longline gear similar to that used in the commercial shark fishery was deployed at randomly selected stations within contiguous 60 nautical mile (n. mi.) grids throughout the GOM. The survey methodology and gear design used in those surveys proved effective for capturing many of the small and large coastal sharks regulated under the auspices of the 1993 Fisheries Management Plan (FMP) for Sharks of the Atlantic Ocean (NOAA, 1993). Subsequent to the initial 1995 pilot study, annual surveys were implemented to assess the status of shark stocks throughout the GOM and in the U.S. western North Atlantic Ocean from the Florida Keys to Cape Ann, MA. In 2000, survey methodology and design was modified to include deeper waters where snapper and grouper species occur.

Beginning in 2001 and continuing to the present day, surveys, gear and methods for the SEFSC/MS Lab surveys have been standardized and remain constant. The #15/0 non-offset steel circle hook was adopted as the standard hook type, and the sampling unit remains a 1 n. mi. longline fished for 1 hr. Longline stations are proportionally allocated within 60 n. mi. sampling zones within depths 9 - 366 m (5 - 200 fm). Fifty percent of the effort is allocated to the 9 – 55 m (5 - 30 fm) depth strata, 40% is allocated to the 55 – 183 m (31 - 100 fm) depth strata and 10% (or at least 2 sampling sites per sampling zone) is allocated between 183 – 366 m (100 – 200 fm).

Protocol 1: Survey Operational Protocol.

A. Vessel requirements

Bottom longline projects can be supported by a variety of vessels and the minimum vessel requirement for longline operations is defined by a vessel's hydraulic system capabilities or electrical power capabilities sufficient to run a self-contained longline reel/hydraulic reservoir system. Vessel length can be a concern since with larger vessels it is possible to support a wider variety of scientific objectives than with smaller vessels due to work space and crew and scientist's accommodations. On a large vessel it is possible to remain at sea for longer periods and to work a full 24 hr work cycle, whereas on a smaller vessel it is generally not feasible to carry enough crew and scientists to support a 24 hr work cycle in addition to greater limitations for days away from port (limitations for provisions and bait supply). Smaller vessels are more prone to be affected by sea conditions, but on the other hand, they are more maneuverable than larger vessels and the shorter distance from the ship's deck to sea surface facilitates closer contact with large specimens brought alongside. SEFSC projects have been conducted from vessels ranging in length from 40 - 225 ft (12 - 67 m), with at sea endurance from 1 - 23 days.

B. Measure survey gear

A small longline spool holds approximately 5 n. mi. 4.0 mm diameter monofilament line (900 - 1200 lb; 401.8 - 535.7 kg test); up to 10 n. mi. for large spools. Prior to bottom longline deployment, the mainline is attached to a high flier (radar reflecting buoy). High fliers are attached at both ends of the deployed mainline for visual reference and to facilitate gear retrieval. As the bottom longline is deployed the vessel's GPS is used to determine distance covered. Because of the constant cutting and reattachment of the mainline and potential loss of sections of line over the course of a survey, the mainline is not marked in sections and the length of mainline deployed is based on GPS intervals. One-hundred gangions (monofilament leaders with AK snap attachment clip and hook) are attached to 1 n. mi. of mainline approximately equidistantly (about every 60 ft or 31 m) throughout the set. Gangion spacing is determined by GPS (i.e., at 1/10 n. mi. 10 evenly spaced gangions should have been deployed) and n. mi. increments are relayed to the gear set crew by hand-held 2-way radios. An electronic beeper (interval based on vessel speed) is often used to determine component attachment intervals. Weights (5 - 10 kg) are attached to the beginning, middle and end of the bottom longline to prevent gear from rising in the water column, as well as to minimize horizontal movement. After the end weight is attached to the bottom longline gear, the mainline is cut and attached to the second high flier. Prior to the gear haulback, the mainline is reattached to the remaining line on the spool.

Buoy lines (or drop lines) are continuations of the mainline and are not separate gear components but are created by deploying an adequate amount of mainline monofilament for tethering high flier buoys to the bottom longline gear. Buoys/high fliers are used only on the distal ends without a mid-set buoy.

To create high flier buoy lines for attaching the high fliers to the mainline:

1. The bottom depth is determined from the ship's echo sounder and the first high flier is attached to the mainline and deployed.
2. As the vessel steams forward enough mainline is deployed to achieve at least a 3:1 buoy line scope ratio based on the bottom depth (i.e., to create a high flier buoy line in 20 m bottom depth 60 m of buoy line are required; often for deepwater sets the ship's GPS can be used to determine when an adequate amount of buoy line has been deployed, otherwise buoy line lengths are estimated by the gear set crew).
3. Once the correct amount of buoy line is deployed the first bottom weight is attached to begin the 1 n. mi. measure of bottom longline gear.
4. Gangions and the midweight (after 50 gangions are deployed) are attached followed by the remaining 50 gangions.
5. The vessel slows and the final longline set weight is attached and the buoy line for the last high flier deployment is created by deploying enough mainline for a 3:1 scope ratio.
6. The vessel stops and the set is completed by cutting the mainline and attaching the final high flier.

C. Longline set and haulback events

To properly calculate catch per unit effort (CPUE) and a variety of additional statistical analyses, it is important to document longline set, gear soak and longline haulback events. There are 4 critical events; first high flier deployed (beginning of the set), last high flier deployed (end of the set), first high flier retrieved (beginning of haulback) and last high flier retrieved (end of haulback). Minimum data elements required for each event are the date, time, bottom depth, latitude and longitude.

D. Set duration and length of longline deployed

Standard sets are 1 hr in duration with 100 hooks attached along 1 n. mi. of mainline. There are a number of situations that can affect the haulback duration including; high catch rates where data reporting requirements and tagging necessitate slowing the retrieval process, large fish entangling gangions and other gear components, gear entanglement with bottom obstructions and turtle encounters. If the haulback is delayed, some of the hooks deployed near the end of the set soak for more than the 1 hr standard. However, since the time event is recorded for the final high flier brought aboard to end the haulback, extended haulback times are documented.

Gear soak time is an important element in calculating fishing effort (catch per unit effort, CPUE, expressed as the number of captures by species/100 hook hr). Soak time is defined during SEFSC surveys, and often for other surveys, as the time between deployment of the last high flier to end the set to the time of retrieval of the first high flier to begin haulback. Since the beginning and end of the soak period are essential data elements, soaks that deviate from the standard 1 hr can be accounted for during data analysis. It is possible to use critical events for re-evaluating effort calculations if needed since the 4 critical events are data elements (begin set, end set, begin haulback and end haulback).

E. Direction of sets

Ideally, sets are conducted parallel to depth contours with reasonable effort made to maintain a uniform bottom depth and vessel speed throughout the set. Maintaining a uniform set depth can be difficult and may not be feasible when setting gear along areas of high relief or in high winds or currents. Gear is set from the stern of the vessel and communications between the deck crew and helmsman are maintained via hand held two-way radios. Set procedures are generally standard and should be maintained for consistent effort. Primary set procedures and events include; wheel house to deck notification of the set event, deploying the first high flier, attachment of the first weight, attaching gangions at approximately equidistant increments, attachment of the mid-weight, completing gangion deployment, attaching the last weight, and deploying the last high flier to mark the set termination point.

F. Bottom topography

Inherent to broad-based bottom longline surveys is the likelihood of encountering a variety of bottom types and profiles. Research and charter vessels are, as a rule, equipped with echo sounders suitable for providing an electronic view of bottom profiles. Using an echo sounder to assess bottom type is often complicated by a number of factors that include bottom depth, bottom type (soft bottom verses hard bottom), sea conditions, vessel speed across bottom and echo sounder settings. It is recommended that experienced ship helmsmen operate echo sounders since a number of variables may affect generated displays.

G. Location of sampling sites and procedures to use if a station occurs over rough bottom

Examining the sea bottom topography with an echo sounder prior to a bottom longline set can help prevent gear damage and survey delays. Typically, when bottom profiles appear prohibitive the ship's helmsman and a scientific representative cooperatively assess the bottom profile. For circumstances where the sea bottom profile appears to be prohibitive for gear deployment, a survey protocol was established to allow for movement of a pre-selected station 0.5 n. mi. in any direction from the originally selected point provided a newly selected point does not fall outside of the predetermined depth strata (if designated) or sampling zone. For most surveys this is generally sufficient for relocating a set. For those cases when a 0.5 n. mi. search does not provide an alternative set location, after discussion between the helmsman and the watch leader or chief scientist, the station is dropped. A new location may be selected through a predetermined randomization procedure that follows the criteria of the original survey design. In some cases, it is necessary to move stations due to ship traffic, commercial or recreational fishing activity, shoals or other factors that preclude setting 1 n. mi. of longline gear.

H. Gear damage and repeat criteria

Gear damage can lead to lost survey time. Often gear damage can be minimized by being cognizant of bottom features along longline set locations, maintaining proper set direction, and maintaining proper vessel orientation during haulback (e.g., caution not to tangle the line in the propeller). However, gear damage can occur even during the best of circumstances. Notations concerning gear damage are made in the data sheet comment section and are a matter of record for associated bottom longline data. Data collected from sets with gear damage is not disregarded. If gear damage was a result of bottom features, the set is not repeated. If gear damage was a result of a problem with gear deployment (e.g., the mainline breaks during the set) the set is repeated.

I. Criteria for determining the success of a bottom longline set and procedures to use if a set was unsuccessful

A fully successful bottom longline set is a scenario where established protocols were followed throughout the set and during haulback there were no indications of damage or fouling of the mainline, gangions or hooks. Longline sets that are considered less than successful are those where less than the full set of 100 hooks are retrieved or components of the longline gear were damaged or lost. Less than successful sets are not repeated but the number of hooks retrieved and any associated problems are noted as comments associated with longline data. The only scenario where an unsuccessful set would be repeated is when an unsuccessful set was the result of a correctable oversight by the set crew (e.g., bottom weights not used or adequate buoy line not deployed). For bottom longline sets that were inadvertently made across unfavorable bottom and the longline gear was damaged, entangled or lost, those sets are not repeated and the resultant data (from the longline portion that was retrieved) is included as a component of the survey data.

J. Gear and bait preparation

Gear and bait preparations are completed before arrival at the set location. Gangions and hooks are inspected for damage and baited with relatively uniform sized bait pieces suitable for the survey hook type. SEFSC surveys use a single bait type (i.e., Atlantic mackerel, *Scomber scomberus*) to minimize variability attributable to bait. When possible, baits are double hooked by passing the hook barb twice through each bait piece. Typically, 11 kg (25 lb) of bait is sufficient for a 100-hook set.

K. Vessel and winch operation during set deployment and retrieval

Vessel speed while deploying the longline is 9.2 km/hr (5 knots). The ship's GPS is used to measure the 1 n. mi. set that begins when the first bottom longline weight is attached to the mainline; the 1 n. mi. set terminates after the last hook and last bottom longline weight is attached. The high flier buoy lines are not included in the 1 n. mi. measure. Communications between the ship's helmsmen and set crew are maintained via hand-held 2-way radios. Gear haulback speed can vary from 0 - 5 knots depending on sea conditions and the number of captures. Often the capture of large specimens or numerous captures necessitates a slowing or stopping of the vessel.

L. Defining Responsibility

The lead scientist for bottom longline surveys (i.e., chief scientist or field party chief), is responsible for preparing survey instructions, assembling the scientific compliment, handling logistics for loading gear and bait deliveries, and selecting stations. Station locations are made available to vessel command at least one month prior to surveys. Daily scientific operations, sampling procedures and routine gear maintenance (preparing the gear for the set) are the responsibility of the lead scientist or designated watch leader. The lead scientist or watch leader participates in discussions with the ship helmsman or other officer on watch concerning the feasibility of conducting longline operations when a predesignated location may need to be moved due to ship traffic, fixed platforms or presence of prohibitive bottom features.

M. Survey Design

The locations for longline sets are chosen at random and are not directed sampling based on capture of a particular elasmobranch or teleost. A random number generator (with replacement) is used to first generate a random line of latitude or longitude (depending on the direction of the continental shelf) with the second coordinate a random distance from shore; locations can also be selected at random with an ArcGIS program. Stations are proportionally allocated based on the depth strata area within sampling zones. Stations are not designated day or night stations but are occupied opportunistically with minimum steaming time between stations. Gear is fully deployed, allowed to soak for 1 hr (the time after the last buoy during the set and the retrieval of the first buoy to begin the gear haul) then retrieved. Catch data are collected as catch comes aboard during the haul or after the haul is complete for catch that needs to be biologically sampled.

N. Biological Data Element

Biological data collected for captures generally follows established SEAMAP protocols and includes (but is not limited to); total length, fork length, standard length (optional but often collected for reef fish species), precaudal length for sharks, sex, reproductive development stage and whole weight. Specimen photographs that are cataloged with station number identifiers (or even specific hook numbers) are valuable for confirming identifications. Tagging is an important component of longline studies and a data format for including a tag number for a particular capture is essential. Often biological sampling of specimens is required and data sheets and data entry formats facilitate sample tracking.

During current MS Lab surveys on large NOAA ships, a computerized data collection system allows monitoring of survey events. Collecting biological and associated data with NOAA ship scientific computer systems (SCS) and NMFS fisheries scientific computer systems (FSCS) creates a wider and more accurate range of survey data options. Many data elements (in particular gear events) can be collected in real time with weatherproof laptop computers that are either hard wired via network ports or use Wi-Fi transmission to the ship's primary computer server. Utilizing the ship's SCS data allows Greenwich Mean Time (GMT) time/date stamps and the corresponding position (latitude/longitude) to be associated with set and haulback events (e.g., buoy and gangion deployments and retrieval, hook status, catch status). FSCS biological data collection options accommodate a full range of biological elements needed to describe species landed (i.e., lengths, weights, tagging information, special sampling) and can be used in real time as catch is landed or for sampling after the gear haulback is completed. Edit routines are useful for identifying potential data problems. The SCS/FSCS data are edited and archived with ACCESS software. If Time-Depth-Recorders (TDRs) are used, TDRs are sequentially numbered to match the numbered gangions and TDRs are downloaded if there was a capture, or once weekly to clear memory. TDRs are typically attached 1 – 2 m above the hook. TDR files are named with the convention to match specimen numbers (vessel code/ survey number/ station number/ hook number).

Use of a catch landing sling (operated with hydraulic cranes) facilitates accurate length and weight measurements for catch that typically would be too large to land. The 3 m length landing sling (constructed with a stainless steel frame and mesh-panel landing basket) can be used to haul large specimens to the ship's rail or onboard for collection of biological data, conduct accurate tagging, and for tissue sampling. The landing sling is equipped with a remotely controlled electronic scale with digital readout and output port. The landing sling can be used aboard larger research platforms and requires little or no vessel modifications.

Protocol 2: Longline Gear Construction, Repair and Maintenance

Longline gear components and repair

Bottom longline gear is useful for assessing a variety of fishery issues. Whether target species are large elasmobranchs or small teleosts, bottom longline gear components and survey strategies can be modified to suit survey objectives. For surveys using bottom longline gear, standardization of operation protocols (for specific projects) is desirable in order to compare time series data between surveys or across years. Gear standardization is relatively uncomplicated provided survey design parameters and gear components are properly documented. Data elements that describe longline sets should include pertinent gear specifics (i.e., number of hooks and hook type).

Longline gear is typically deployed and retrieved with a hydraulic longline reel. Bottom longline gear typically consists of monofilament mainline, monofilament gangions (monofilament leaders with AK snaps for attaching gangions to the mainline and hooks attached with crimps), monofilament blocks, a rail roller or line retrieval block, high fliers, polyball floats, and weights.

Reel, blocks, and rollers

The longline reel is either connected to the vessel's hydraulics or may be equipped with a self-contained hydraulic unit. Mainline is spooled onto the reel prior to sailing. Mainline may be deployed or retrieved through monofilament blocks; sometimes a roller mounted on the ship's cap rail is used for retrieval. If the position of the longline reel is not optimal, the mainline may then be redirected by the use of a series of monofilament blocks to the point of setting or haulback. The longline reel, rail roller, and blocks should be inspected and greased regularly and protected from the elements when not in use.

Mainline

Factors that affect the choice of mainline test strength for longline surveys include target species size, vessel specifics and maneuverability, and bottom type. SEFSC bottom longline surveys use 4.0 mm diameter monofilament mainline (900 - 1200 lb; 401.8 – 535.7 kg) test monofilament mainline due to the capture of large elasmobranchs and the variety of bottom types in survey areas. Mainline should be inspected regularly for damage and replaced in sections or in its entirety as needed. Sections of mainline are joined using appropriately-sized metal crimping sleeves and a hand-held crimping tool on the appropriate setting, or joined with specialized knots. Care should be taken to ensure that crimps are neither too loose (line will pull through) or too tight (sleeve will cut into line and reduce strength under tension). Monofilament mainline should be protected from light exposure when not in use.

Gangions

For SEFSC bottom longline surveys, gangions are constructed using monofilament leaders, AK snaps for attaching gangions to the mainline, #15/0 non-offset steel circle hooks and crimping sleeves. For SEFSC projects gangions are made of 3.0 mm diameter monofilament (700 - 730 lb; 312.5 – 325.9 kg test). Gangion length depends on the freeboard of the vessel (most SEFSC gangions are 12 ft or 3.7 m) and length should be consistent within the scope of each project. A sufficient number of gangions should be assembled prior to sailing to allow for 2 full sets of gear (for SEFSC bottom longline surveys, 200 gangions). Gangions should be inspected after each set for signs of wear or damage to monofilament, weakening of AK snaps, and bent or damaged hooks. Sleeves should be crimped using the appropriate setting on the crimping tool to avoid crimps that are either too loose or too tight.

High fliers

High fliers are used at the beginning and end of each set and are comprised of diamond-shaped radar reflectors (metal or plastic) attached to the end of a buoy pole (typically 12 - 15 ft; 7.3 - 4.6 m length) which passes through a center through-hole in an inflatable polyball float. High fliers are weighted at the bottom with metal counter weights to ensure that they remain upright in the water. Reflective tape is placed on the radar reflector and during inclement weather and at night, battery-operated strobe lights are attached to the pole near the radar reflector. The high flier assembly is tethered to an additional polyball float to facilitate recovery during haulback. Monofilament and snaps connecting elements of the high flier assembly should be checked regularly for wear, particularly when monofilament is used to connect weights to the high flier pole. Strobe lights should be checked daily and batteries changed as needed.

Weights

Short sections of anchor chain are used to weight the longline along the bottom and to help maintain position on the bottom by hampering drift. Weights are typically used at the beginning, middle, and end of each set for SEFSC surveys. Additional weights may be used in areas of high current velocity, however, excessive use of weights can result in the high flier being pulled under the surface or the mainline breaking. Monofilament and AK snaps used to attach weights to the mainline should be inspected daily for wear and damage.

Buoy lines

Buoy lines used to attach high fliers to the distal ends of a bottom longline set are simply additional mainline monofilament deployed between the last weight and the high flier. Generally, a 3:1 (3 times bottom depth) scope ratio is adequate for buoy line lengths. At the beginning of a set, the high flier is deployed and the navigation coordinates are recorded. Using the ship's navigation system (GPS) sufficient buoy line scope is estimated (based on the bottom depth as read from the ship's echo sounder) prior to attaching the first weight to the mainline. After all hooks and the last weight are attached, the navigation coordinates are again recorded and scope ratio is again estimated prior to attachment of the final high flier.

New Technology

Collecting biological and associated data during longline surveys with NOAA ship scientific computer systems (SCS) and NMFS fisheries scientific computer systems (FSCS) creates a wider and more accurate range of survey data options. Many data elements (in particular gear events) can be collected in real time with weatherproof laptop computers that are either hard wired via network ports or use WiFi transmission to the ship's primary computer server. Utilizing the ship's SCS data allows Greenwich Mean Time (GMT) time/date stamps and the corresponding position (latitude/longitude) to be associated with set and haulback events (e.g., buoy and gangion deployments and retrieval, hook status, catch status). FSCS biological data collection options accommodate a full range of biological elements needed to describe species landed (i.e., lengths, weights, tagging information, special sampling) and can be used in real time as catch is landed or for sampling after the gear haulback is completed. Edit routines are useful for identifying potential data problems. The SCS/FSCS data are edited and archived with ACCESS software.

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